MAPPING LAND USE AND HABITAT CHANGE IN THE NERRS: REVISED STANDARD OPERATING PROCEDURES

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I. Introduction

In 2009, the National Estuarine Research Reserve System (NERRS) completed the suite of documents that are intended to guide mapping in the NERRS. These documents include the Habitat Mapping and Change (HMC) Plan, the NERRS Classification Scheme and associated documentation and implementation protocols. These documents are available on the NERRS Intranet site and on the NERR Internet site. The purpose of developing the HMC Plan and NERRS classification scheme was to establish consistency in mapping habitats and boundaries across the NERRS. Due to inconsistency in mapping standards and protocols, it has been impossible to characterize the habitats contained within our reserve system and how they are changing over time. Consistent terminology and standards will support the research, stewardship, education and outreach priorities of the NERRS and foster partnerships with state, regional and federal partners.

Having said that, theses SOPs promote flexibility in mapping strategies (e.g. heads up digitizing or semi-automated classification), on accuracy assessments approaches (at the class or sub-class level), and geography (the entire reserve vs. a specific geography or habitat type) based on site-based resources and local mapping applications. The critical principle stressed by these SOPs is completeness of ***documentation***.

The goals of the NERR HMC planning effort are to: (1) develop a framework for mapping habitats and reserve/watershed boundaries to characterize and communicate at site, regional, and system-wide scales short-term variability and long-term trends in adjacent land use/land cover, local sea level, and spatial changes in reserve habitats; and (2) examine the impact of land use within adjacent watersheds, as well as changes in local sea level, on reserve habitats. Towards this end, the HMC Plan objectives are to: 1) map land cover/land use and associated land cover changes in reserves and their watersheds; 2) model elevation and tidal datums in reserves and elevation in adjacent watersheds; and 3) enhance capacity within the NERRS to map, model and disseminate information on estuarine habitat trends and associated linkages with anthropogenic and climatic stressors.

These Standard Operating Procedures (SOPs) detail the methodology for developing and submitting boundary shapefiles and habitat maps to the Centralized Data Management Office (CDMO) in compliance with the HMC Plan. Adherence to the SOPs will establish system-wide consistency among reserves and ensure that QA/QC standards are met for all mapping products developed and made publicly accessible by the NERRS. Consistency in standards will facilitate analysis of habitat change within and among reserves and communicate trends in habitat change within the NERRS.

Mapping within the reserve watersheds will be conducted by the NOAA Coastal Services Center as part of the Coastal Change Assessment Program. Since the NERRS does not dedicate funding for mapping, the only requirement for reserves is to map their areas of perpetual interest (i.e., areas targeted for repeated high resolution mapping over time to monitor change) in accordance with the requirements in this SOP and pursuant to approved site-based habitat mapping and change plans.

While the SOPs provide guidance on mapping reserve habitats outside areas of perpetual interest, mapping these habitats is voluntary until such time that the NERRS dedicate additional funding for mapping. However, since most reserves receive funds for mapping from sources other than the NERRS for specific applications, compliance with the standards within the SOP is encouraged to the extent consistent with funding requirements so that these products can be posted on the CDMO website.

The SOPs focus on the methodologies, processes, and requirements for submitting the following mapping products:

- Reserve and watershed boundaries
- Land Use/Land Cover maps at multiple scales
- Change analysis
- Digital Elevation Models (DEMs)
- Processes for submitting products to the Central Data management Office (CDMO)
- Reserve Habitat Mapping and Change Plans

These SOPs revise the original SOPs developed in September, 2009 in the following ways:

- Supervised semi-automated classification methods is suggested as a classification strategy to hold errors between consecutive mapping constant in situations where a heads-up digitized product has not been done and where supervised semi-automated classification can detect reserve habitats at the sub-class level;
- A detailed structure for submitting and documenting accuracy assessments has been included;
- Procedures for readme files has been included;
- Nomenclature and processes for submitting photos and readme files associated with accuracy assessments has been included;
- Processes for submitting high resolution imagery has been updated
- A QA/QC review process for high resolution imagery has been included to support reserves in editing their shapefiles and associated metadata to ensure they are SOP compliant before being submitted for review.

These SOPs will be evaluated and updated annually to address lessons learned, emerging issues, or the adoption of new national or NOAA mapping standards.

II. Boundaries

Kutcher et al. (2008) recommended the implementation of a two-level approach to facilitate the objectives identified by Neider et al. (2002) that require characterization of land cover/land use both within reserve boundaries and in the watersheds that drain into them. The approach utilizes existing

resources within NOAA and the US Fish and Wildlife Service (USFWS), using (1) Coastal-Change Analysis Program moderate-resolution data automatically classified to characterize reserve watersheds, and (2) recently developed classification and collection protocols (compatible with national wetland mapping standards) to characterize land cover and habitat types on reserve properties at higher resolution. This two-tier approach has the advantage of using consistent, efficient, and readily available C-CAP protocols to track changes in land use/land cover, percent impervious surface, and canopy cover within reserve watersheds at no cost and minimal effort to the NERRS, while also utilizing the NERRS Classification System to provide a standardized format to track habitat change at higher resolution within reserve boundaries. The recommendation for a two-level approach was approved for implementation by the reserve system in 2007 (SWMP Revision, 2007), and the specific data requirements related to reserve and watershed boundaries are detailed below.

A. Reserve Boundaries

Reserve boundaries submitted to the CDMO must adhere to specific requirements or they will not be accepted for posting on the CDMO website:

1. Federal Geographic Data Committee (FGDC) compliant metadata. All reserve boundaries must have complete FGDC compliant metadata attached that details: (1) the base maps used to develop the boundaries and associated details about the base imagery or products, (2) the methodology for developing the boundaries, (3) projection, (4) the date the boundary was produced, (5) contact information, and (6) other required information. The FGDC compliant metadata for boundaries is specified in the standard metadata information accessible at the ESRI Support Center (http://support.esri.com/).

2. Projection: All reserve boundaries must be submitted using Transverse Mercator projection which minimizes size and shape distortion within each UTM zone to 1:1000.

3. Frequency: Reserve boundaries must be submitted whenever a boundary amendment is made due to acquisition or inclusion of additional lands. Re-submitting the revised boundary map should be the final step in modifying boundaries and can only be completed after the Federal Register notice has been published announcing approval of the boundary amendment. The revised boundary shapefile must adhere to FGDC requirements and projection standards identified above.

B. Watershed Boundaries

There are two, and at some reserves three, scales of watersheds that are mapped as part of the NERRS HMC Plan. The largest scale is the estuarine basin(s) within which the reserve is contained. It has been determined based on a flow analysis that most closely corresponds to a US Geological Survey (USGS) 8-digit Hydrologic Unit Code (HUC). This boundary has been developed for all reserves (except Jobos Bay and Kachemak) and has been uploaded to the CDMO web site. The methodology for creating the

estuarine basin is described in the metadata of each reserve's boundary file.

Reserves have also identified an intermediate watershed scale, the targeted watershed boundary. Targeted watersheds represent those watersheds that directly flow into and impact the habitats within reserves. In some cases, the targeted boundaries may correspond to the estuarine basin described above (e.g. Narragansett Bay NERR, RI), but in most cases, these are distinct boundaries. Targeted watersheds can represent: 1) the USGS 14 digit HUCs that only encompass the river systems directly flowing into the reserves; or 2) boundaries based on local knowledge. For example, a targeted watershed may encompass the watershed of a reserve's tributary such as the York River of the Chesapeake Bay that can bring water impacted by land uses down-stream of a reserve into the reserve on an incoming tide. These watershed boundaries have been uploaded to the CDMO web site.

In the case of some reserves, there may even be a third scale reflecting a small watershed adjacent to a particular reserve component. These smaller watersheds consist of the land cover/land uses that directly impact that particular reserve component. Due to the small size of these basins, the C-CAP 30 m resolution imagery may be too coarse to be used to evaluate changes in land use and their associated impacts on reserve habitats. The 30-m resolution must also be evaluated as to its capability to support analysis of the adaptive capacity of reserve habitatsto respond to climatic impacts such as sea level rise. Higher resolution imagery may be required for these purposes. Chesapeake Bay, VA and Elkhorn Slough NERR, CA have both identified watershed boundaries at this small scale.

Watershed boundaries must have all metadata attached to meet the standard FGDC metadata requirements including: (1) the methodology in which boundaries were developed, (2) contact information, and (3) projection. All estuarine and targeted basin boundaries are to be projected using an Albers projection, and targeted and small watershed boundaries are projected in a Transverse Mercator projection to preserve alignment with the reserve boundary projections.

III. Land Cover and Land Use Maps

Neider et al. (2002) established a strategy to implement a system-wide land use/land cover change analysis protocol. The document identified conceptual and technical objectives for tracking land use/land cover changes and led to the development of a NERRS Habitat Mapping and Change committee, as well as a Habitat Mapping and Change Technical Committee (HMCTC). The HMCTC developed strategies for (1) identifying and acquiring the appropriate imagery, (2) interpreting and classifying data, and (3) processing, formatting, and distributing the results. The technical tools and methods supporting those objectives are summarized in the following section and are organized based on the two-level approach (moderate and high resolution) of Kutcher et al. (2005) mentioned above. Different land cover/land use mapping strategies are described below and detailed data specifications are provided in Table 1.

A. C-CAP Moderate Resolution/High Classification Accuracy Land Cover Maps of Watersheds

NOAA Coastal Services Center (CSC) provides the moderate resolution land cover data of each reserve's watershed and/or targeted watershed (except Jobos Bay and Kachemak) to the CDMO. Data are acquired and processed through a repeatable semi-automated protocol developed by Dobson et al. (1995) and implemented on a rotating five-year collection cycle since 1996. The protocol uses Landsat TM 30-m resolution, multi-spectral satellite imagery that is run through a series of spectral analyses and field verifications. The protocol is developed to achieve 85% overall mapping accuracy.

NOAA CSC has also provided maps characterizing impervious cover, canopy cover (produced by the U.S. Forest Service), and land use/land cover change within each reserve's watershed and targeted watershed (except Jobos Bay and Kachemak) to the CDMO. All NOAA CSC products are delivered in a pre-processed C-CAP format and no further processing or quality assurance is required. All maps are delivered in a single standardized Albers projection, which enables site as well as system-wide analysis.

B. High Resolution/High Classification Accuracy Maps of Reserve Habitats of Perpetual Interest

Individual reserves are responsible for the acquisition and processing of high resolution land cover data. Reserves will produce a high resolution/high classification map by classifying the habitats to the Subclass level of the NERRS Classification Scheme. Habitats or Perpetual Interest, or "Priority Habitats are defined as land cover that are monitored over the long-term by the Reserves and are mapped every ten years. These areas/habitats of perpetual interest can represent a specific geographic area (e.g., Redfish Bay in the Mission-Aransas NERR) or a specific habitat type throughout the entire reserve (e.g., wetlands). Smaller reserves may identify all inter-tidal and supra-tidal habitats within the Reserve boundary as "priority habitats", while larger reserves may choose to select representative areas or priority habitats to monitor over the long term. For the purposes of producing baseline maps, those reserves not including sub-tidal habitats as areas of perpetual interest should classify sub-tidal habitats within the area of perpetual interest to the highest level of detail possible, even if this is just a placeholder at the subsystem level (e.g., denoting *estuarine sub-tidal haline*).

If the reserves choose to include non-priority habitats in the high resolution/high classification land cover maps, they have the option of classifying the non-priority habitats to the Class Level. An accuracy assessment is required and reserves can decide based on available resources if an accuracy assessment will be completed at the class level for the entire map and/or at the sub-class level for habitats of perpetual interest (see Section D below). The strategy must be recorded in the "High Resolution Land Cover Readme File" document (see Section V.). Methodology applied to acquire and process high resolution land cover data must be documented in the site-based habitat mapping and change plan.

Compatibility of data among the various reserves, regardless of image acquisition technique,will be achieved through the use of the following standardized mapping, classification, and ground-truthing

techniques that were developed by the NERRS.

- Regardless of imagery used to support classification, the HMCTC encourages consideration of the use of supervised semi-automated classification mapping techniques combined with field verification to hold errors constant while re-mapping. This process will help standardize classification methods so that change detection is capturing change in habitat and not change in human interpretation. The Coastal Services Center will support reserves in processing imagery with E-cognition software in the semi-automated process. The HMCTC recognizes, however, that this strategy may not meet the needs of all reserves and that reserves should choose the strategy that best meets their resource and application needs. It is critical that regardless of the method, that the metadata and readme file provide complete documentation.

- Reserves are required to classify Areas of Perpetual Interest to the subclass level of the NERRS Classification Scheme, with or without descriptors and/or modifiers.

- Accuracy assessments for Areas of Perpetual Interest should, to the extent possible, be conducted at the sub-class level of the NERR Classification Scheme (see Accuracy Assessment section below).

C. High Resolution/Moderate Classification Accuracy Maps of Reserve Habitats Outside of Areas of Perpetual Interest

If high resolution data are available for sections of the reserve that are outside of "priority habitats," the reserve may submit a map of these habitats classified to the Class Level of the NERR Classification Scheme. The mapping protocols and standards required for maps of "Areas of Perpetual Interest" also apply to these maps; however, no change analysis every ten years is required. An accuracy assessment at the Class Level of the NERRS classification scheme is also required. Methodology used to acquire and process high resolution land cover data must be documented in the site-based habitat mapping and change plan.

Table III-1. Data specifications for habitat mapping.

	Moderate Resolution/ High Classification Accuracy	**High Resolution/ Moderate Classification Accuracy**	**High Resolution/ High Classification Accuracy**
Resolution	30-meter	1-meter or 3-meter (Reserves should refer to using highest resolution imagery available)	1-meter or 3-meter (Reserves should refer to using highest resolution imagery available)
Scale	1:100,000	1:12,000 or 1:24,000	1:12,000 or 1:24,000, or higher (i.e. 1:5000)
Minimum mapping requirement	Watershed	Inter-tidal, supra-tidal	Inter-tidal, supra-tidal
Data source	LandSat Thematic Mapper multispectral satellite imagery	Varies depending on reserve If using supervised semi-automated classification, RGB,and IR is required. Lidar is helpful.	Varies depending on reserve If using automated classification, RGB,and IR is required. Lidar is helpful.
Data type	Raster	vector, polygon (shapefile)	vector, polygon (shapefile)
Data processing	C-CAP semi-automated protocol conducted by CSC	Heads up digitizing or semi-automated process if possible (CSC will support)	Heads up digitizing or semi-automated process if possible (CSC will support)
Target minimum mapping unit	0.09 ha (0.22 ac)	0.1 ha (0.25 ac)	0.1 ha (0.25 ac)
Classification	C-CAP ordered list	NERRS Hierarchical Classification System (class level)	NERRS Hierarchical Classification System (sub-class level)
Metadata	FGDC Compliant - produced by NOAA CSC	FGDC Compliant – produced by reserves	FGDC Compliant – produced by reserves
Projection	Albers	Transverse Mercator	Transverse Mercator
Collection Interval	5 years	Minimum of every 10 years	Minimum of every 10 years
Accuracy Assessment		Conducted at the Class Level of the NERR Classification scheme	Conducted at the Sub- Class Level of the NERR Classification scheme unless prohibitive based on resource availability.

D. Accuracy Assessment - Ground-truthing Procedures

Accuracy assessments are designed to provide quantitative information on the overall accuracy of the entire habitat classification dataset at the class level of the NERRS Habitat Classification Scheme for areas not identified as areas of perpetual interest and at the sub-class level for habitats within the areas of perpetual interest. At a minimum, the accuracy assessment analysis will involve the collection of *in situ* reference data with a real time corrected Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) unit capable of real time positioning (± 10 feet) and categorizing the habitat using the NERRS Classification Scheme.

Researchers collecting data in the field should be aware of potential issues caused by the GPS data and/or errors in the spatial position of the source imagery. Care should be taken to ensure that the correct polygon is assigned to the correct reference site. This error can be minimized by using the highest accuracy GPS unit available, collecting GPS data during periods of low PDOP (Dilution of Precision), and minimizing the spatial errors of the initial source dataset. The accuracy of the GPS unit used for reference site selection should be noted in the description of the methodology of the accuracy assessment. The GPS points in the accuracy assessment should be projected using UTM. Please convert the projection before submitting the data file.

At this time, no minimum level of accuracy is required for the accuracy assessment analyses. The only requirement is that an accuracy assessment is conducted, and data are used to create a shapefile, and the methodologies used by the reserve are submitted along with the land cover dataset.

1. Methods for selecting reference data points

When conducting the accuracy assessment, a stratified random sampling methodology is recommended for selecting reference points since it will help ensure that all classes and/or sub-classes of habitats of interest are accounted for in the accuracy assessment. However, this type of sampling design might not be possible where information on class spatial distribution is unknown prior to field work (see Congalton and Green, 2009 for a complete description of reference site selection).

Fifty samples per sub-class is a general rule of thumb for the minimum sample size needed to assess the accuracy of a specific sub-class (Congalton and Green, 2009). However, this will most likely not be possible for maps including multiple habitat classes and sub-classes due to the time and cost of collecting reference site information. If the reserves use less than 50 samples per subclass, document in the readme file what method was used to select sample sites.

2. Methods for classifying the habitat at reference data points

There are many methods for collecting reference data with a wide range in validity, reliability, and expense. According to Congalton and Green (2009), there are three steps to data collection: 1) locate the sample sites, using the GPS coordinates selected in the lab, 2) determine the sampling size needed to characterize the sites; and 3) collect information. To ensure objectivity and consistency, reference

data must be independent of any training data used to create the base map. Data collection considerations include:

- **Site Location and Delineation** - Spatial coordinates (e.g., latitude/longitude, UTM) and associated projection information (e.g., projection, datum) are necessary to navigate to the appropriate sampling site in the field. See Congalton and Green (2009) or other references for more details on this subject.
- **Observation versus Measurement** - Simple observation is generally sufficient for describing the site. However, some classification schemes are dependent on measurements to differentiate between classes. The sampling site size needs to match the minimum mapping unit (Walker and Garfield (2006): NERRS mapping protocol).
- **Timing of Data Collection** - Reference data should be collected as close as possible to the date of the imagery used to make the map.
- **Information Collected** - Collected data need to include all information necessary to correctly classify the sample into one of the categories in the classification scheme. In addition, the following information should be included:
    - **Site identification** - At a minimum, a unique numerical code for the sampling point; other types of codes include: coding for field (F) or aerial photo (A), regional or management description, and sample number. For example: F _LAID_23 = the 23rd field reference site in Laidlaw Park.
    - 2. **Observation level** - used as an indicator of the potential accuracy of the observations a '1' being most accurate and '4' being the least accurate

        1 = Walk through stand or polygon

        2 = Viewed from road or trail adjacent to stand

        3 = Viewed from afar (i.e. road or ridge opposite of stand)

        4 = Photo interpreted in office
    - **Classifiy habitat** - Each field point will be classified to the subclass level in "areas of perpetual interest" and to the class level in areas outside "areas of perpetual interest", in accordance with the NERRS Classification Scheme (see Congalton and Green, 2009 for a complete description of methods for classifying habitats at reference point). When selecting points, ensure that you obtain the appropriate number of reference points to support the goals of the assessment (i.e. for class or sub-class level assessment).
        - **Photo**- photo or map name or number used to delineate the sampling unit

E. Accuracy Assessment Error Matrix Table

The data collected during accuracy assessment are used to create an error matrix that ranks the

number of test samples assigned to each land cover class against their "correct" assignments as verified through the reference data (Congalton and Green, 2009).

The matrix will provide producer accuracy (errors of omission – due to missing data) and user accuracy (errors of commission – due to misclassification) for the classification level of interest within the habitat dataset (see table III.2). An un-weighted Kappa statistic coefficient must also be computed (Congalton and Green, 2009). This statistic compares the results of the reference dataset and the classified imagery at either the class or sub-class level of the habitat classification scheme depending on the purpose of the map.

The following figures provide examples of the error matrices for habitats classified to the class (Figure III-2) and the computation of the Kappa statistic (Figure III-3.).

		Reference				
		2210. Aquatic Bed	2230. Streambed	2260. Emergent Wetland	2560. Scrub-shtrub Wetland	**Total (Users Accuracy)**
GIS Map	2210. Aquatic Bed	15	3	1	1	**20**
	2230. Streambed	4	18	3	2	**27**
	2260. Emergent Wetland	4	5	16	4	**29**
	2560. Scrub-shtrub Wetland	1	2	4	17	**24**
	Total (Producers Accuracy)	**24**	**28**	**24**	**24**	**100**

Table III-2. Example of accuracy assessment matrix at the class level. Note that white cells represent agreement between the classified imagery and the validation dataset; grey represents disagreement.

Figure III-3. Calculation of Kappa statistic (*K*) using data from Figure 1.

$$\text{observed agreement } (P_O) = \frac{\text{sum of diagonal}}{\text{sum of matrix}} = \frac{15 + 18 + 16 + 17}{100} = \mathbf{0.66}$$

$$\text{chance agreement } (P_C) = P_1P_1 + P_2P_2 \ldots = [(24/100)*(20/100)] + [(28/100)*(27/100)] + [(24/100)*(29/100)] + [(24/100)*(24/100)] = \mathbf{0.25}$$

$$K = \frac{P_O - P_C}{1 - P_C} = \frac{0.66 - 0.25}{1 - 0.25} = \mathbf{0.55 \text{ (moderate agreement)}}$$

H. Other Accuracy Considerations

Although the NERRS does not required reserve maps to meet a minimum level of accuracy, the FGDC Wetland Subcommittee has released a draft Wetland Mapping Standard (Heber, 2007), which outlines wetland mapping protocols intended to apply to any federally-funded inventory of geospatial wetland data. This standard is of significance to the NERR System which will be mapping wetland areas. FGDC protocols require vector data output derived from 1:12,000 scale (or less desirable 1:24,000) with source data at 1-m resolution (1:63,360 at 5m for Alaska) to have (1) 68% positional accuracy within 5-m on the ground, (2) 98% producer's accuracy (error of omission) in delineating wetland areas from non-wetland areas, and (3) 85% attribute accuracy (correct wetland classification). Source data can be aerial photography or satellite imagery. These standards will apply to the NERRS mapping standards for mapping wetlands produced with federal dollars. Achieving the FGDC Wetland Subcommittee standards and conducting the associated accuracy assessments for wetlands is highly recommended for reserve system maps uploaded to the CDMO.

Registration error, resulting from misalignment or distortion in the imagery, generates false differences during change detection. Therefore an estimate of the source imagery's spatial accuracy must also be included in the accuracy assessment. Commercial vendors of ortho-rectified satellite and aerial imagery typically provide such an assessment. If the spatial accuracy of the source imagery is unknown (e.g. locally geo-referenced aerial photography), a sampling procedure that compares points visible on the imagery with their "true" reference positions should be performed. A spatial accuracy assessment that uses Global Positioning System (GPS) and, if available, high spatial accuracy reference imagery should be reported using a Root Mean Square Error (RMSE) and an associated 95% confidence interval for the horizontal coordinates (x,y) (Congalton and Green, 2009). It is important to understand that reference imagery and GPS coordinates will have their own sources of error and therefore a sufficient number of reference positions need to be collected to derive a meaningful estimate for the RMSE of an image product.

IV. Change Analysis

Every ten years, reserves are expected to conduct a change analysis of the "area/habitats of perpetual interest". No guidelines for conducting a change analysis have been developed, but reserves are encouraged to use well-documented, peer-review methodologies. The reserves can use one of the methods below for conducting the analysis. The first is to overlay the baseline vector map onto the new source data, and use automated methods for modifying polygons and attributes to reflect actual changes in the landscape in a systematic manner. The other approach is to use an imaging software, such as E-cognition or Imagine, to compare the land cover classifications on the baseline and new data sources. Classification of unchanged habitat polygons will remain the same, while dynamic habitats or those under anthropogenic or climate-related stress will require re-classification or boundary changes. The method used to conduct the change analysis must be described in in detail in the metadata and readme file. The methods should include relevant information about each map

layer.

V. Required GIS Datasets

A. Naming Convention for Data Products Submitted to the CDMO

To facilitate the sorting and access of reserve data products on the CDMO website, all data products must be submitted using the following title format: **Reserve Code_File Code_Date Code**as outlined in the following table. For multiple priority habitat areas (i.e. Iona, Stockport [Hudson River NERR]), a reserve must submit separate shape files and accuracy assessment files for each habitat area. The specific codes are identified in Table V-1 below.

Table V-1. Naming codes for Habitat Mapping and change data products.

Reserve Name	Reserve Code
Ashepoo Combahee Edisto Basin, South Carolina	ACE
Apalachicola Bay, Florida	APA
Chesapeake Bay, Maryland	CBM
Chesapeake Bay, Virginia	CBV
Delaware	DEL
Elkhorn Slough, California	ELK
Grand Bay, Mississippi	GND
Great Bay, New Hampshire	GRB
Guana Tomalato Mantanzas, Florida	GTM
Hudson River, New York	HUD
Jacques Cousteau, New Jersey	JAC
Jobos Bay, Puerto Rico	JOB
Kachemak Bay, Alaska	KAC
Mission Aransas, Texas	MAR
Narragansett Bay, Rhode Island	NAR
North Carolina	NOC
North Inlet-Winyah Bay	NIW
Old Woman Creek, Ohio	OWC
Padilla Bay, Washington	PDB
Rookery Bay, Florida	RKB
San Francisco Bay, California	SFB
Sapelo Island, Georgia	SAP
South Slough, Oregon	SOS
Tijuana River, California	TJR
Waquoit Bay, Massachusetts	WQB
Weeks Bay, Alabama	WKB
Wells, Maine	WEL
File Type	**File Code**
Reserve Boundary	RB
C-CAP Land cover data	CCAPLC
C-CAP Change Analysis	CCAPCA
Impervious Surface	IMP

Canopy Cover	CAN
Digital Elevation Models	DEM
Digital Elevation Models of priority habitat - single priority area/habitat	DEMPH
Digital Elevation Models of priority habitat - multiple priority areas/habitats †	DEMPH_XX
High resolution priority habitat map - single priority area/habitat	HRLCPH
Accuracy Assessment map for high resolution single priority area/habitat map	HRLCPH_AA
High resolution priority habitat map - multiple priority areas/habitats †	HRLCPH_XX
Accuracy Assessment map for high resolution multiple priority area/habitat map†	HRLCPH_AA_XX
Change analysis of high resolution habitat - single priority area/habitat	HRCAPH
Accuracy Assessment map of change analysis high resolution single priority area/habitat map	HRCAPH_AA
Change analysis of high resolution habitat – multiple priority areas/habitat †	HRCAPH_XX
Accuracy Assessment map of change analysis high resolution of multiple priority areas/habitat map †	HRCAPH_AA_XX
High resolution habitat maps - outside of priority areas/habitats	HRLC
Change analysis of high resolution habitat maps – outside of priority areas/habitats	HRCA
Photos associated with Accuracy Assessments	[Reserve Code]_ [Habitat Subclass level]_[YYYYMM]
Mapping Tiers†	**Tier Code**
Reserve Boundary	RB
Estuarine Basin Boundary	EBB
Targeted Watershed Boundary	TWB
Small Watershed Boundary	SWB
Date	**Date Code**
Reserve Boundary - Year produced	YYYY
C-CAP Land cover data – Year imagery acquired	YYYY
Impervious Surface – Year imagery acquired	YYYY
Canopy Cover – Year imagery acquired	YYYY
Digital Elevation Models – Year elevations acquired	YYYY
Change Analysis – Original imagery year and New imagery year	YYYY_YYYY
High resolution maps – Month and year imagery acquired	YYYYMM

*Note: All C-CAP related data products must also include a tier code and should use the following title format: **Reserve Code_File Code_Tier Code_Date Code**

† Note: A two letter code will be used to denote specific priority areas or habitat types that have been mapped. For example, if all wetlands within the reserve were mapped as the priority habitat, the two letter code would be WL. If a specific geographic area was mapped, such as Redfish Bay, the code RB would denote the location of the mapping effort.

Examples case studies of standardized naming scheme:

- Elkhorn Slough NERR updates its reserve boundary in November of 2008 pursuant to new acquisitions. They submit their boundary file titled **ELK_RB_2008**.

- Narragansett Bay NERR submits a baseline map of area outside its *Area of Perpetual Interest* that was generated from high resolution land cover imagery collected in April of 2009 for the entire reserve. The map was submitted in November, 2009. They submit their Land Cover shapefile titled **NAR_HRLC_200904** and the Accuracy Assessment shapefile titled **NAR_HRLC_AA_200904**.

- Mission-Aransas NERR submits a baseline map of one of their four priority habitats (Redfish Bay) that is the target for habitat change analysis. The high-resolution imagery was collected in October 2008 and the map was submitted in June 2009. The Land Cover shapefile is titled **MAR_HRLCPH_RB_200810** and the Accuracy Assessment shapefile is titled **MAR_HRLCPH_AA_RB_200810**.

- Narragansett Bay NERR submits a change analysis map of their reserve habitats based on new high resolution imagery acquired in April of 2014. The map was submitted in August 2014. The Land Cover shapefile is titled **NAR_HRCA_2008_2014** and the Accuracy Assessment shapefile is titled **NAR_HRCA_AA_2008_2014**.

- Mission-Aransas NERR submits a change analysis map of one of their four priority habitats (Redfish Bay) based on new high resolution imagery acquired in October 2013. The map was submitted December 2013. The Land Cover shapefile is titled **MAR_HRCAPH_RB_2008_2013** and the Accuracy Assessment shapefile is titled **MAR_HRCAPH_AA_RB_2008_2013**.

- ACE Basin NERR submits their C-CAP change analysis for their estuarine basin from year 1997 to 2001. The file is titled **ACE_CCAPCA_EBB_1997_2001**.

- North Inlet Winyah Bay Submitted an Accuracy Assessment with 3 core habitats of perpetual interest: emergent wetlands-persistent, sea grass beds, scrub-shrub. They submit 3 photos that were taken during the accuracy assessment process in April, 2010. The photos are submitted in the zip file as NIW_2131_201004; NIW_2261_201004; NIW_2271_201004.

B. Metadata Report

Reserves are required to submit a metadata report for the land cover and accuracy assessment shapefiles. The following table contains the fields that must be completed, and required information for the Description field.

Table V-2. FGDC compliant metadata report. Criteria for Accuracy Assessment is in blue text.

Citation Originator (name, organization, mailing address, and telephone number) Publication Date Geospatial Presentation Form [ESRI fills in details]
Description ***Abstract*** (A brief narrative summary of the data set) • At a minimum, include the following information about the mapped areas ✓ The base map (i.e. aerial photography/digital imagery) and scale or resolution of imagery ✓ Date base map was taken ➢ Land cover/land use: **Note** if areas were delineated on paper or electronic map or by manual or automated methods ; for example, "heads-up" (i.e., on-screen) digitizing, list technques, i.e. screen viewing scale (e.g., 1:3000 to 1:5:000); and automated techniques, i.e. supervised classification ➢ Accuracy Assessment: sampling techniques, i.e. stratified random, date (mon/year) of sampling ***Purpose*** (A summary of the intentions with which the data set was developed) Brief narrative of the data se

Time Period (time frame for which the data is relevant) Date and time Currentness reference (The basis on which the time period of content information is determined)
Status of the Data Progress (state of the dataset) Maintenance &update frequency (The frequency of update to base map)
Spatial Domain [ESRI fills in details] Bounding Coordinates In decimal degrees In projected or local coordinates
Keywords Theme (Common-use words or phrases used to describe the subject of the data set. We require the following key words: National Estuarine Research Reserve, tidal wetlands (and other key habitats), habitat map) Thesaurus (Reference to a formally registered thesaurus or a similar authoritative source of theme keywords)
Data Storage and Access Information Access constraints (Restrictions and legal prerequisites for accessing the data set) Use constraints (Restrictions and legal prerequisites for using the data set after access is granted)
Spatial Data Organization Information [ESRI fills in details]
Spatial Reference Information [ESRI fills in details about coordinate systems entered by user] Horizontal Coordinate System Planar: Grid Coordinate System (i.e. UTM Zone 17) Geodetic Model: Horizontal Datum Name (i.e. North American Datum of 1983)
Entity and Attribute Information

C. Attribute Table for Land Cover Shapefile

Consistent data and data standards within attribute tables is critical for accumulating data over time within a reserve, combining data among reserves, and for initiating automated QA/QC processes by the CDMO on the shapefiles. For this reason, the format and data within attribute tables must be consistent across reserves. For habitat maps submitted by the reserves to CDMO, each row of the attribute table represents a habitat unit (i.e., polygon) and each column provides information describing that particular unit. All attribute tables must contain, at a minimum, the columns listed in Table V-3. The columnar format of the attribute table is the backbone of the high resolution land cover inventory, and therefore, is essential in allowing data interoperability between reserves and with other data producers and users. Standardize formatted attribute tables will enable analysis of reserve habitats and associated change over time across the NERRS. The attribute tables will be reviewed for conformance with the SOPs during the QA/QC process prior to posting maps to the CDMO website.

Table V-3. Minimum standard attribute columns required for high resolution habitat maps (modified from Walker and Garfield 2006).

Parameter	Column Name	Description
System (Numeric)	Sys_Num	Level 1 classification using numeric codes.
System (Nominal)	Sys_Nom	Level 1 classification using nominal description.
Subsystem (Numeric)	SubSys_Num	Level 2 classification using numeric codes.

Subsystem (Nominal)	SubSys_Nom	Level 2 classification using nominal description.
Class (Numeric)	Cls_Num	Level 3 classification using numeric codes.
Class (Nominal)	Cls_Nom	Level 3 classification using nominal description.
Subclass (Numeric)	SubCls_Num	Level 4 classification using numeric codes.
Subclass (Nominal)	SubCls_Nom	Level 4 classification using nominal description.
Descriptor (Numeric)	Dsc_Num	Level 5 classification using numeric codes.
Descriptor (Nominal)	Dsc_Nom	Level 5 classification using nominal description.
Modifier (Nominal)	Mod_Nom	Level 5 classification using nominal description.
Feature Area	Area (in hectares)	Describes, in appropriate units, the area of the feature.

D. Attribute Table for Accuracy Assessment Shapefile

As with the Land Cover table, consistent data and data standards within the Accuracy Assessment attribute table is critical for accumulating data over time within a reserve, combining data among reserves, and for initiating automated QA/QC processes by the CDMO on the shapefiles. For Accuracy Assessment maps submitted by the reserves to CDMO, each record (row of the attribute table) represents information about the ground-truthing unit (i.e., polygon) and each column represents the data collect for that particular unit. All attribute tables must contain, at a minimum, the columns listed in Table V-4. The attribute tables will be reviewed for conformance with the SOPs during the QA/QC process prior to posting maps to the CDMO website.

Table V-4. List of required and optional attributes for Accuracy Assessment maps (developed by HMCTC committee). Definition of Classification levels are described in Table 2 and in Walker et al. 2006.

Parameter	Column Name	Description
REQUIRED ATTRIBUTES		
Reserve Code: (Text)	Res_Code	three-letter code assigned by HMCTC to each reserve
Component Code (Text)	Comp_Code	two-letter code assigned by reserve
User Class (Numeric)	UCls_Num	level assigned by individual creating map
User Subclass (Numeric)	USubCl_Num	level assigned by individual creating map
User Subclass (Nominal)	USubcl_Nom	level assigned by individual creating map
Accuracy Assessment Point (Numeric)	AA_ID	unique number assigned to ground-truth point
Producer Class (Numeric)	PCls_Num	level assigned by individual conducting ground-truthing
Producer Subclass (Numeric)	PSubcl_Num	level assigned by individual conducting ground-truthing

Producer Subclass (Nominal)	PSubcl_Nom	level assigned by individual conducting ground-truthing
Agree (Text)	Agree	column checked if user and producer classification of land cover type agree
Not Agree (Text)	Not_Agree	column checked if user and producer classification of land cover type **DON'T AGREE**
OPTIONAL ATTRIBUTES		
User Dominant (Nominal)	UDom_Nom	level assigned by individual creating map
Producer Dominant (Nominal)	PDom_Nom	level assigned by individual conducting ground-truthing
Descriptor (Nominal)	Dsc_Nom	common habitat name by Reserve

E. Error Matrix Table

Reserves must submit at least one Error Matrix table per land cover shapefile in the readme file. A table is only required for land cover types that were checked during the Accuracy Assessment ground-truthing. For area/habitat of perpetual interest, analysis is conducted on land cover classified at subclass level. For land cover outside of the area/habitat of perpetual interest, analysis is conducted on land cover classified at class level. A table should not combine two classification levels.

Land cover types listed in the error matrix need to be named according to the NERRS Classification Scheme and both the Numeric Value and associated Nominal Value for land cover types (i.e. Cls_Num: 2260 and Cls_Nom: Emergent Wetland).

Table V-5. Error Matrix Table -Analysis of Class Level Data

Error Matrix Table -Analysis of Class Level Data

		Reference Data (Producer)						
		2220 Reef (Intertidal)	2250 Unconsolidated Shore (Intertidal)	2260 Emergent Wetland (Intertidal)	2340 Emergent Wetland (Supratidal)	2350 Scrub-Shrub Wetland (Supratidal)	Total Mapped	**User's Accuracy (%)**
Mapped Classification (User)	2220. Intertidal Reef	5	0	0	0	0	5	100
	2250. Unconsolidated Shore (Intertidal)	0	9	0	0	0	9	100
	2260. Emergent Wetland (Intertidal)	1	1	47	2	0	51	92
	2340. Emergent Wetland (Supratidal)	0	0	3	20	2	25	80
	2350. Scrub-Shrub Wetland (Supratidal)	0	0	0	7	3	10	30
	Total Visited	6	11	50	29	5	100	
	Producer's Accuracy (%)	83	82	94	69	60		

User's Accuracy (percentage of map-derived samples that are correctly mapped)
Computation: Number of correct classification divided by the column total.

Producer's Accuracy (percentage of field-derived samples that are correctly mapped)
Computation: Number of correct classes in each row divided by the row total number of samples.

Overall Accuracy (= Observed Agreement) (percentage of correctly mapped samples)
Computation: The sum of the main diagonal elements of the error matrix divided by the total number of samples.

(5+9+47+20+3)/100=86/100=0.84

Chance Agreement (percentage of chance agreements between map-derived and field-derived classifications)
Computation: Sum of the products of corresponding User's Accuracy and Producer's Accuracy values

$$\sum((\text{user's accuracy/total}) * (\text{producer's accuracy/total}))$$

[(5/100)*(6/100)] + [9/100)*(11/100)] + [(51/100)*(50/100)] + [(25/100)*(29/100] + [(10/100)*(5/100)] = 0.003 + 0.0026 + 0.255 + 0.0725 + 0.005 = 0.338

Kappa Statistics:

Observed agreement (P_O)	84%
Chance agreement (P_C)	34%
Kappa (K)	0.758

Kappa (K): $[(P_O - P_C) / (1 - P_C)] = (0.84-0.338) / (1-.0.338) = 0.758$

F. Habitat Photographs

Reserves must submit one photograph of each Habitat of Perpetual Interest, (priority habitat). The photographs should be submitted as a JPEG format, and a maximum file size of 500 K. Photographs must be named according to the standard naming conventions identified in Table V-1 (p.12-13).

G. Readme File

Reserves must submit a "Readme File" that describes the land cover datasets. The following table lists the information required by the HMCTC. Also, if more than one area/habitat of perpetual interest is mapped, the Reserves are responsible for assigning two letter codes (e.g., Redfish Bay = RB) to the habitat area and including a description of the codes in the metadata report and "read me" file. A blank form of the "readme" file is provided in Appendix A.

Table V-6. Required information for the "readme" file. Blue text is provided throughout the document to assist with its completion – please delete all blue text when you have finished your ReadMe file.

Overview of Land Cover Mapping Efforts
Description of Dataset [i.e. high resolution priority habitat map – multiple priority areas/habitats]
Purpose [List the reserve's statement and a "blanket" statement from the NERRS GIS program (HMCTC will provide a "blanket" statement about the NERRS GIS program)]
Supplemental [Provide location of papers that are associated with the reserve's mapping efforts (i.e. technical paper references, location of other Reserve GIS products, photographs of priority habitats)]
Overview of Accuracy Assessment Process
Sampling Design: [Please provide detailed information about how the accuracy assessment sampling design (i.e., random, stratified

random, stratified aligned random) was developed. Stratified random is the preferred method, so please provide additional justification if another method was used.]
Level of Classification: [Please describe the level of the NERRS classification scheme (i.e., class, subclass) used to conduct the accuracy assessment. Please provide additional justification if something other than the subclass level was used.]
Land Cover Classifications: [Please provide a brief description of the sampling points assigned to each land cover category (i.e., number of correct classifications, number of misclassifications) and explain how this affected the producer, user, and overall accuracy.]
Sampling Method for Field Classification: [Please provide a description of the sampling methods (i.e., quadrat, transect) used to classify land cover at each accuracy assessment sampling point. Please list any additional information gathered at each sampling site.]
Photographs: [Please list the photograph names and associated habitats. You may provide a link or contact information for other photographs of sampling points.]
Error Matrix: [Please use one of the following tables as a guide for development of your error matrix.]
Kappa Statistic: [Please complete the following table.]
References: [Please provide full citation of references mentioned in text]

VI. GIS Dataset Submission Process

A. Organizational Structure

The HMCTC is a sub-committee of the System-Wide Monitoring Program (SWMP) Data Management Committee (DMC). The key priorities of this sub-committee are to ensure Quality Assurance/Quality Control (QA/QC) compliance with the standards established by the HMC Plan, provide technical assistance, set yearly priorities, and revise the SOPs as necessary. Specifically, the role of this sub-committee will be to:

- Provide technical assistance to reserves in support of mapping and elevation strategies.
  The committee will support the mapping community by assessing and coordinating training for all aspects of mapping including implementation of the NERR classification scheme, change analysis, accuracy assessments, etc. Committee members will also assist reserves in specific mapping needs.

- Ensure that all map products submitted to the CDMO comply with the standards established by the HMC Plan and referenced in this SOP.
  The committee will review all data products submitted by reserves to ensure that it has FGDC compliant metadata, attribute tables, and appropriate projections, scales, imagery resolution, nomenclature, accuracy assessments, etc. If a map product does not comply with the requirements of the plan, it will be returned for editing. No mapping product will be forwarded to the CDMO that does not meet the standards identified in the HMC Plan SOPs.

- Provide leadership to improve coordination within the NERR mapping community to identify and address emerging needs and issues.
  The committee will address emerging needs and issues that relate to mapping. This will include

such responsibilities as adoption of new mapping protocols and standards by the FGDC and NOAA. The committee will be responsible for updating any new adopted protocols/standards in these SOPs. The committee will also identify methods for streamlining access to data and enhancing integration within the NERR mapping community. Finally, this committee will establish system-wide priorities that lead to the yearly development of action plan and/or strategic proposals to be submitted to the NERR Strategic Committee. In drafting these proposals, this committee will integrate to the maximum extent possible with the other DMC committees and the SWMP oversight committee.

- Monitor progress towards meeting annual operating plan goals.
  All reserves are required to develop baseline maps and change maps based on high resolution imagery every ten years, as identified in the NERRS three year annual operating plan. The committee will be responsible for evaluating progress towards these goals and support reserves having difficulty meeting their goals.

- Improve integration with the other phases of SWMP.
  One of the Co-Chairs of this habitat mapping and change sub-committee will be represented on the SWMP oversight committee and will be responsible for overall coordination with the other SWMP sub-committees.

- Approve reserve Habitat Mapping and Change Plans.
  The committee will be responsible for reviewing all HMC Plans developed by individual reserves. The committee will also coordinate reviews by NOAA's National Geodetic Survey and Center for Operational-Oceanographic Products and Services. Once all comments are addressed, the reserve's HMC Plan will be approved by ERD. HMC Plan guidelines are detailed in Appendix A.

B. QA/QC Review Process

The reserve must submit the high resolution land cover datasets as a zip file that should contain the following information:

1) Land cover and Accuracy Assessment shapefiles and associated metadata reports, and ArcMap projection file

2) One photographs of each habitat of perpetual interest

3) Readme file that describes the land cover dataset, including information about the geographic extent of the classification, level of the classification (e.g. priority habitats classified to subclass level, non-priority areas classified to class level), and methodology used to produce datasets.

The reserve is responsible for uploading the zip file to the FTP site on the CDMO website. The CDMO will conduct the 1st Review of the files (an "Exploder" script that will automatically check the file to ensure that all the required files are attached and nomenclature is in the correct format). When the files pass the 1st Review stage, the HMC GIS oversight committee representative will download the files and perform the 2nd and 3rd Reviews, as outlined in the following section. When the files have successfully passed all three Review stages, the files will be uploaded to the CDMO ftp site, where it

will be processed and made made available to the public as shapefiles and KML files for Google Earth.

After each review stage, the reserve will receive an email with the results of the review. The report will either outline the problems with the submission or notify the reserve that the submission has successfully passed the review. If there are problems, corrective steps must done by the reserve before the next review stage can be initiated. After the reserve makes the corrections, all of the files must be re-zipped and uploaded to the CDMO GIS directory; once the files are determined to be in compliance, the next stage of the review will be initiated.

C. Checklist for Review Process

1ST QA/QC Review - Completeness of the ZIP file

1. Must submit the following datasets
   - ✓ Land Cover (LULC) shapefile (must be vector dataset)
   - ✓ Accuracy Assessment (AA) shapefile
   - ✓ Hi Resolution Land Cover Readme file
   - ✓ Photographs (one per habitat listed in Error Matrix Table
2. Projection files for LULC and AA shapefiles provided and projected in following coordinate system:
   - ✓ Geographic Coordinate System: GCS_North_American_1983
   - ✓ Projection Coordinate System: Nad_1983_UTM [Reserve zone]
3. Filenames are consistent with NERRS standardized filename naming conventions
4. Images are in JPEG format and not greater than 500 K

2nd QA/QC Review - Completeness of the datasets

1. Attribute Tables
   - ✓ Used required fields in Table V-2 (Land Cover map) and Table V-3 (Accuracy Assessment map)
   - ✓ Used required NERRS classification names in land cover and AA shapefiles (see Kutcher et al. 2008 for descriptions
2. Metadata Reports (land cover and AA shapefiles
   - ✓ Entity and Attribute Information field contains description of fields in Attribute Tables
   - ✓ Definition and Definition Source for attributes not listed in Table V-2 and Table V-3
3. High Resolution Land Cover Readme File
   - ✓ Description of land cover dataset (i.e. high resolution priority habitat map)
   - ✓ Purpose of Mapping Efforts: List reserve's statement and a "blanket" statement from NERRS GIS program
   - ✓ Supplemental: Provide information associated with the reserve's mapping efforts (i.e. technical paper references, location of other Reserve GIS products, photographs of priority habitats)
   - ✓ AA Sampling design described. (i.e. random, stratified random, stratified aligned random)
   - ✓ Level of classification (i.e. class, subclass) used to conduct AA provided.
   - ✓ Land Cover Classifications used in AA
   - ✓ Sampling Method for Field Classification
   - ✓ Information about photographs of priority habitats
   - ✓ Error Matrix Table(s) and associated Kappa Statistics

5. Habitat photographs
   - ✓ Provided a photograph of all priority habitats listed Error Matrix Table(s)

3rd Review - Correctness of information in Files

1. Land Use/Land Cover (LULC) Attribute Table
   - ✓ Correct relationship between Nominal and Numeric Values of a category (i.e. 2200 [CLS_NUM] Intertidal Haline [CLS_NOM])
   - ✓ Correct spellings of classification names (i.e. Unconsolidated Bottom, Emergent Wetland)
2. Accuracy Assessment (AA) Attribute Table
   - ✓ Correct relationship between Nominal and Numeric Values of a category (i.e. 2200 [CLS_NUM] Intertidal Haline [CLS_NOM])
   - ✓ Correct spellings of classification names (i.e. Unconsolidated Bottom, Emergent Wetland)
   - ✓ Relationship between the User and Producer category correct (User: 2220 - Producer: 2230 = Not Agree)
3. LULC and AA Metadata Reports
   - ✓ Information is clearly communicated and spelled correctly
   - ✓ Consistency between information in metadata report and Readme file
4. High Resolution Land Cover Readme File
   - ✓ Information is clearly communicated and spelled correctly
   - ✓ Consistency between information in metadata report and Readme file
   - ✓ Calculations in Error Matrix Table(s) and associated Kappa Statistics correct
5. Habitat photographs
   - ✓ Provided a photograph of all priority habitats
   - ✓ Consistency between name of photograph and habitat (i.e. photo: NIW_1243_200603 habitat: Marine Intertidal Unconsolidated Shore)

VII. Literature Cited

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Walker, S.P. and Garfield, N. 2006. *Recommended Guidelines For Adoption and Implementation of the NERRS Comprehensive Habitat and Land Use Classification System.* Report for the Estuarine Reserves Division, NOAA/NOS/OCRM, Silver Spring, MD, NERRS.NOAA.GOV.

Appendix A: Template for "Readme" File

[RESERVE NAME] **NERR**

Date of Last Update:

Overview of Land Cover Mapping Efforts

Description of Dataset (See metadata report for more information about dataset)
[i.e. high resolution priority habitat map – multiple priority areas/habitats]

Purpose
[List the reserve's statement and a "blanket" statement from the NERRS GIS program (HMCTC will provide a "blanket" statement about the NERRS GIS program)]

Supplemental
[Provide location of papers that are associated with the reserve's mapping efforts (i.e. technical paper references, location of other Reserve GIS products, photographs of priority habitats)]

Overview of Accuracy Assessment Process

Sampling Design:

[Please provide detailed information about how the accuracy assessment sampling design (i.e., random, stratified random, stratified aligned random) was developed. Stratified random is the preferred method, so please provide additional justification if another method was used.]

Level of Classification:

[Please describe the level of the NERRS classification scheme (i.e., class, subclass) used to conduct the accuracy assessment. Please provide additional justification if something other than the subclass level was used.]

Land Cover Classifications:

[Please provide a brief description of the sampling points assigned to each land cover category (i.e., number of correct classifications, number of misclassifications) and explain how this affected the producer, user, and overall accuracy.]

Sampling Method for Field Classification:

[Please provide a description of the sampling methods (i.e., quadrat, transect) used to classify land cover at each accuracy assessment sampling point. Please list any additional information gathered at each sampling site.]

Photographs:

[Please list the photograph names and associated habitats. You may provide a link or contact information for other photographs of sampling points.]

Error Matrix:

[Please use one of the following tables as a guide for development of your error matrix.]

MAPPED TO CLASS LEVEL

PDBNERR 2004 Accuracy Assessment Table

Mapped Classification (User)	Reference Data (Producer)					
	2210. Aquatic Bed	2230. Streambed	2260. Emergent Wetland	2270. Scrub-Shrub Wetland	Total Mapped	User's Accuracy
2210. Aquatic Bed	15	3	1	1	20	
2230. Streambed	4	18	3	2	27	
2260. Emergent Wetland	4	5	16	4	29	
2270. Scrub-Shrub Wetland	1	2	4	17	24	
Total Visited	24	28	24	24	100	
Producer's Accuracy						

MAPPED TO SUBCLASS LEVEL

PDBNERR 2004 Accuracy Assessment Table

Mapped Classification (User)	Reference Data (Producer)					
	2213. Rooted Vascular	2236. Mud	2261. Persistent	2274. Narrow-lvd Evergreen	Total Mapped	User's Accuracy
2213. Rooted Vascular	15	3	1	1	20	75%
2236. Mud	4	18	3	2	27	66.6
2261. Persistent	4	5	16	4	29	55.2
2274. Narrow-lvd Evergreen	1	2	4	17	24	70.8
Total Visited	24	28	24	24	100	
Producer's Accuracy	62.5%	64.3	66.7	70.8		

Kappa Statistic:

[Please complete the following table.]

Observed agreement (P_O)	
Chance agreement (P_C)	
Kappa (K)	

References:

[Please provide full citation of references mentioned in text]

Appendix B: Checklist for QA/QC Review of GIS Dataset Submissions

Item	Task	Y/N
	Hi-Resolution Land Cover Readme File Completeness Section (refer to SOP manual)	
	Overview of Mapping Efforts	
41	Description of land cover dataset provided	
42	Purpose of mapping project provided, including "blanket" statement from NERRS GIS program	
43	Original Spatial Reference Information	
44	Supplemental: Provide information associated with the reserve's mapping efforts (i.e. technical paper references, location of other Reserve GIS products, photographs of priority habitats	
	Overview of Accuracy Assessment Process	
45	Sampling design described. (i.e. random, stratified random, stratified aligned random	
46	Sampling Method for Field Classification described	
47	Information about photographs of priority habitats provided. (Also can provide a link or contact information for other photographs)	
48	Error Matrix Table(s) provided	
49	Kappa Statistics provided	
50	Photographs provided for all listed Habitats of Perpetual Interest and associated habitat name listed	
51		
52		
53		
54		
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56		
57		
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59		
60		
	GIS Dataset Correctness Section - (3rd Review Stage)	
71	Information in Metadata Report's Description field for both shapefiles is clearly communicated and spelled correctly	
72	Information in Readme File is clearly communicated and spelled correctly	
73	Correct spellings of classification nominal categories (i.e. Intertidal Haline)	
74	Correct values of classification numeric categories (i.e. 2200)	
75	Correct relationship between Nominal and Numeric categories (i.e. 2200 and Intertidal Haline	
76	Correct relationship between User and Producer category recorded in Agree or "Not_Agree field (i.e. User: 2220 - Producer -2230 = Not Agree)	
77	Values in Error Matrix Table (s) corresponds with values in Agree and "Not_Agree fields	
78	Calculations in Error Matrix Table(s) and associated Kappa Statistics correct	
79	Consistency between information in metadata report and Readme file	
80	Habitat photo corresponds with filename (i.e. emergent wetland - filename: NIW_2260_200604.jpg)	
81		
22		
83		

84		

Appendix C: Methodology for Mapping Habitat Change - forthcoming